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MOSST HQM DEMAND MODEL
METHODOLOGY

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FOREWORD

This paper describes the methodology of the highly qualified manpower demand model developed by MOSST. Its purpose is mainly to contribute to the methodology of manpower modelling and, therefore, the paper does not provide any actual projection results.

The model has been in existence since 1977, and has been solved on a number of occasions since then. One of the more recent solutions is reported in the MOSST Background Paper on "The Requirements for Engineering Graduates to 1985". Other projections based on the model may be published from time to time.

The model and the associated data bases are used extensively in MOSST's continuing work on highly qualified manpower.

Copies of this paper are available on request from the Communications Services Division, Ministry of State for Science and Technology.

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SECTION 1

INTRODUCTION

The MOSST highly qualified manpower (HQM) demand model and data base was designed to provide the basis for projecting the future requirements for university graduates.

This paper provides a description of the methodology of the model and its various components. The main purpose is to present a concise summary of the model blocks and the calculation algorithms, and of the various classification schemes pertaining to manpower.

Since there exist a number of extensive studies dealing with theoretical questions of manpower projections, discussions of the theoretical aspects are not repeated here, except in cases where this model differs from earlier approaches. The latter situations are dealt with in Section 2 of this paper, where there is a brief examination of the questions of technological stability, the production function implications, and the linkages between manpower studies and the educational system.

Section 3 provides an overview of the model, in flow-chart as well as in algebraic form.

Earlier attempts to project manpower requirements did not have the benefit of large econometric models such as the CANDIDE model and had to rely on rather crude projections of the industrial structure of the economy. This study uses the CANDIDE framework for the purpose of deriving the future industrial employment structure which constitutes an important input for many of the occupational demand estimates. The use of the CANDIDE model is described in Section 4.

This study is one of the first major applications of the occupational data collected in the 1971 Census under the Canadian Classification and Dictionary of Occupations (CCDO). Section 5 provides the definition of HQM which is based on this dictionary and discusses the occupational classification scheme adopted for use in the model.

The need to replace personnel due to death, emigration and retirement constitutes a significant, and in many cases, the major source of demand for university graduates. The algorithm that is used for estimating attrition is described in Section 6.

Since the model is intended to generate estimates of the demand for university graduates, particular attention is given to the educational background of the new labour market entrants. Educational upgrading is discussed in "University Degree Requirements for New Entrants" (Section 7). The transition coefficients for calculating the educational fields of study of the new entrants are based on the 1973 HQM Post-Censal Survey (HQMPS) by Statistics Canada. The use of this data system and the classification scheme adopted, are described in Section 8.

SECTION 2

SOME CONCEPTUAL QUESTIONS

Earlier projections of manpower requirements, especially of HQM requirements, have tended to suffer from a lack of essential information in a number of areas[1]. Consequently, assumptions about many conceptual relationships in those models could not be made explicit. For example, assumptions had to be made about the uniqueness of the occupational structure in relation to a given level of economic output. Other problems arose in connection with the projection of the industrial output, employment and occupational structure which manifested themselves in peculiar production function implications. Also, a major drawback of previous models was that manpower requirement projections could not be readily translated into educational requirements.

The MOSST model for estimating manpower requirements is able to deal more explicitly with these problems, largely as the result of recent data developments. One of the major factors in the development of better manpower information was the publication of the Canadian Classification and Dictionary of Occupations, 1971, and its influence on the classification system used in the 1971 Census of Population and in other data sets. Other factors include the establishment of powerful annually up-dated administrative data banks for several key HQM occupations (it is expected that such data banks will expand to include more of the professions, such as physicians and lawyers); the development of the CANDIDE econometric model of the Canadian economy which provides estimates of the industrial structure of output and employment; and the HQM Post-Censal Survey of 1973 which provides the "field of study" information for university graduates in HQM occupations.

The MOSST model does not provide regional information. Requirements studies on a national level have been criticized for the fact that they ignore the wide regional disparities that exist in Canada. The model restricts itself to HQM, and this group is highly mobile[2], not only nationally but in many disciplines internationally. Nevertheless, the lack of a regional dimension is a weakness of the model which will have to be addressed eventually.

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[1] Ahamad, B. and M. Blaug. The Practice of Manpower Forecasting. A Collection of Case Studies. Elsvier Scientific Publishing Company. Amsterdam - London - New York.

[2] Mobility can be restricted, however, in some professions when there are institutional or language barriers.

Constancy of the Technological Structure

The traditional Leontief approach has been criticized because of its assumptions regarding the constancy of the technological relationships[3]. In the case of manpower requirements projections, this means the assumption of a rigidly determined occupational structure, within each industry, independent of supply. This approach also does not deal with the transition from the technological aspects, which deal with functions that are performed by production factors, to manpower aspects that deal with human beings who change occupations and who, in the same occupation, often have different educational backgrounds.

The MOSST approach attempts to deal with these particular shortcomings, first, by examining the behaviour of the technological coefficients, and by adapting them in those cases where there is evidence of change[4]. Second, the MOSST model makes a clear distinction between the concept of a job function that is performed by persons in a particular occupation, and the qualifications of those persons who carry out such job functions. For example, a particular managerial function might be carried out by a graduate in electrical engineering who, prior to assuming the managerial job, carried out the function of "technical sales". When he left the sales function, his place was taken by a person with a degree in physics whose previous occupation was "mechanical engineering", etc. The assumption is made that, in the aggregate, interoccupational shifts net out to zero. The MOSST model can take explicit account of changes in the occupation/education mix because of two major recent developments in data: the CCDO and its application in the 1971 Census; and the HQMPS. The Census occupations are now defined in terms of work functions rather than qualifications. The HQMPS, on the other hand, provides the particular educational background of all university graduates included in the Census.

The Production Function Implications

In the ideal case, the demand for labour should be estimated in a production function that specifies the labour inputs by type of labour (say, by occupation), and all the other types of inputs, in order to take account of substitution, for example, between

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3 Ahamad, B. and Blaug, M. (1973), op. cit.

4 As noted below, the health and education occupations and several other occupations, the demand for which is not determined by economic and technological factors, were not calculated by the input/output methodology.

engineers and non-labour inputs, but also other labour inputs such as technologists, blue collar labour, etc. Some inputs would be highly substitutable, while others could not be substituted at all. In practice, however, the available data do not permit this kind of disaggregated estimation of production functions.

Earlier models used simpler devices and assumptions to estimate future industrial output, employment and productivity. The choice as to which of these elements should be projected depended on the method used for estimating occupational requirements. One of the two main approaches relates occupations to outputs whereby the growth in the number of persons in a particular occupation is linked to the growth in output (occupations/output coefficients). The other is the projection of the occupational distribution (occupation/industrial employment coefficient method).

The former method is usually advocated because it is claimed to be "less sensitive to cyclical fluctuations in the state of the economy", and because "relating occupational projections by industry directly to industrial output is more in keeping with the concept of manpower requirements than is the occupational distribution approach"[5]. However, business cycle experience shows that output is significantly more volatile than employment, even when the latter is expressed in man-hours rather than man-years. The reason for this is that there is a substantial cost involved in the hiring and training of labour, and this cost grows with the amount of training and education required for a particular occupation. To minimize the costs involved in cyclical labour turnover, employers attempt to reduce the movement of labour in and out of their firms as much as possible. The cyclical changes in employment differ, depending on the category of labour, and are most pronounced for those who are the least skilled. Nevertheless, the changes in the number of people employed in an industry are less than the changes in the volume of output during the course of a business cycle, and from this point of view alone the approach based on occupation/industrial employment coefficient appears to be preferable. Both methods, however, have implications for the underlying production functions that are usually not made explicit.

The MOSST model employs a two-step procedure in estimating occupational requirements. The first is to produce an econometric

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[5]Holland, J., S. Quazi, F. Siddiqui, and M. Skolnik, Manpower Forecasting and Education Policy, A Study prepared for the Commission on Post-Secondary Education in Ontario. Queen's Printer, Toronto, 1972.

model solution[6] that yields the desired projections of industrial output and employment. The second step is to determine the relative importance of the various HQM occupations in the employment totals for each of the industries. (This is done only for those HQM occupations for which the requirements are determined by economic and technological factors.)

The production function employed in the CANDIDE model[7], which is of the Cobb-Douglas type, does not distinguish between different types of labour, and does not take explicit account of the effect that an improvement in the quality of an industry's work force exerts on total productivity. Increases in the occupation/employment coefficients that have actually occurred in several HQM occupations, would therefore be one of the factors accounting for the technological advance that is measured implicitly by the CANDIDE labour demand functions.

Manpower Demand Projections and Educational Implications

In previous manpower demand models, the occupation/education relationship has been the weakest element in the process of deriving educational implications from labour market forecasts. The MOSST model contains innovations in three different areas of this process. As a consequence, the potential for obtaining useful insights into educational trends has been significantly enhanced.

The first of the improvements which have been introduced to the MOSST model is the distinction in the occupational classifications of the educational and vocational training required in each occupational function[8]. This permits the identification of job groups consistent with certain categories of educational and vocational qualifications. In the past, the information on the occupation/education link was mainly the number of years of schooling of persons in the various occupations. Described in those terms, the educational attainment of the incumbents in an occupation could not be taken as reflecting the underlying requirements for that job function.

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[6]Using the CANDIDE model - see Section 4 below.

[7]See Illing, W., CANDIDE Project Paper No. 10, CANDIDE Model 1.0: Labour Demand, Economic Council of Canada, Ottawa, 1973.

[8]As developed in the CCDO - see Section 5 below for a more detailed discussion.

The second area where the MOSST model benefits from new information is the knowledge of the particular field of study in which university graduates have obtained their degrees, cross-classified by occupation and industry[9]. This information is derived from the 1973 HQM Post-Censal Survey[10]. Having the information concerning educational attainments by field of study of persons employed in a particular HQM occupation, it is possible to estimate the probabilities whereby new graduates are likely to enter HQM occupations by various fields of university specialization. The relevant transition coefficients are estimated on the basis of age structure differences in qualifications, and prior knowledge of legal and institutional requirements regarding field of study and degree requirements. Since the model explicitly allows for the fact that there is not necessarily a direct correspondence between occupation and field of study, the implications for the educational sector arising out of the model projections are more firmly based.

The supply of educated manpower can have an impact on the educational qualifications of new entrants into certain HQM occupations (i.e. university degree versus no university degree). Under more plentiful supply conditions, educational upgrading is more common, as is evidenced by the difference in the qualifications of the younger as compared with the older members of many of the HQM occupations. The HQM model provides for such upgrading in certain occupations, based on a quasi-longitudinal approach[11]. This also tends to render the educational implications more explicit.

Education Planning and the HQM Model

The model has not been designed for educational planning, nor should it be used for this purpose. Educational planning must take account of the demand for education. The model projects the demand for university graduates, which cannot be equated with the demand for education. The latter concept is a much more comprehensive one, while the demand for graduates is only one of the many elements that determine the demand for education. The model projections, while having implications for educational policy, cannot be taken, therefore, as a proxy for educational demand.

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9 This information was not available in Canada in 1968 when Meltz and Penz undertook their study on the manpower implications of potential output projections for 1970 commissioned by the Economic Council of Canada. It was necessary for them to estimate the educational distribution within occupations with the assistance of the Department of Manpower and Immigration. See Meltz, N. and G.P. Penz, Canada's Manpower Requirements in 1970, Canada, 1968.

10 See Section 8 below for a more detailed discussion.

11 See Section 7 below for a more detailed discussion.

The impact of the model projections on educational demand is indirect, via labour market conditions. The impact is usually felt with a delay, due to recognition and reaction lags. Manpower projections can help improve the recognition of, and reaction to, emerging job market trends by individuals, through better knowledge about changes in underlying occupational requirements. It is felt that the MOSST model is an improvement over the traditional manpower models because it attempts to make the educational implications explicit, by translating industrial and occupational labour market requirements into requirements for university graduates by field of study. For this reason, its public information function is more specific than that of traditional manpower projections which restrict themselves to occupational information.

Labour Market Demand and Supply

Demand and supply interact to achieve labour market equilibrium, and the one cannot be determined without reference to the other. In fact, over the medium-term, for the next five or ten years, supply factors set the growth parameters, and demand conditions merely affect fluctuations around the underlying trend. The model, having a medium-term horizon, takes supply factors succinctly into account.

Dictated by data availability, the model estimates are carried out in three discrete estimation steps: industry employment; proportion of HQM work functions; staffing of HQM jobs. Sufficient data are available to estimate the first step behaviourally. Because there are only cross-sectional surveys for occupation and HQM characteristics, the other two steps are estimated through an input/output technique. The following are the three steps:

1. Level of employment by industry. This is based on simultaneous econometric estimates using fully-specified labour demand and supply sectors, and disaggregated expenditures, input/output, industrial, and price sectors. The labour sector contains, on the supply side, demographic and participation rate equations; on the demand side, production functions; on the price side, wage and cost equations. In fact, because the model has a medium-term rather than a short-term horizon, supply factors play the dominant role.

2. HQM occupations by industry. The model distinguishes three classes of HQM occupations, defined by their underlying demand determinants: technological, health and education. In the technological block, the model uses "dynamic" coefficients to estimate occupational requirements by industry. In the health and education sector, such factors as the desired level of health services, trends in demography and university enrolment trends, are used to estimate occupational requirements. At this level of the calculations, only work functions consistent with economic growth and industrial structure are being determined and, given the time horizon of the projections, these work

functions cannot be significantly affected by HQM supply factors. In other words, the type of work that is performed in the economy, and the kind of work functions that have to be carried out, are determined by such factors as the composition of expenditures and the state of technology in the various industries, rather than by the degree of oversupply of university graduates.

3. Requirements for university graduates, by level and by field of study. Once the total number of HQM-level man-years that are required due to economic growth and replacement needs have been determined on the basis of the three occupational models, estimates are made of how many of these man-years will likely be filled by university graduates, and by what kind of university graduate. This is analogous to a staffing function. It is at this stage that supply factors play an important role. While the number of HQM man-years that are required for the functioning of the economy are not affected by an excess supply, the "staffing" of such man-years is obviously greatly influenced by the extent to which suitable candidates are available on the labour market.

In view of the relatively large supply of university graduates, the model projections, therefore, are based on the assumption that the proportion of new entrants with a university degree will be higher than the proportion of existing incumbents with degrees. In several occupations, in fact, a degree has become mandatory in recent years. Thus, for example, teachers must now have a degree, even though many of the older members of the teaching profession did not require one at the time they entered. In many HQM occupations, the proportion of degree holders at the beginning of the 1970s was relatively low, but is estimated to be rising rapidly as suitable graduates become available. The large supply of new graduates exerts, therefore, a significant influence on the way in which newly-required HQM man-years are filled, and the model methodology takes this into account.

Field of Study Requirements

The model employs a probability matrix of coefficients reflecting the field of study background of new entrants. The coefficients are based on institutional requirements where they exist, and on information from the 1973 HQMPS, taking account of the experience of the most recent graduates rather than of the general average.

The evidence is that, outside the "controlled" professions, the majority of entrants into HQM occupations have a university degree in a field of study that is related to the occupation. In the controlled professions (e.g. medicine, law, dentistry, etc.), there is a one-to-one relationship between occupation and field of study.

The relationship is stronger for the health and natural sciences occupations than for occupations in education, social sciences and humanities.

There is no reasonable basis for changing this assumption, even in the light of recent supply growth. Supply growth has been high in all fields of study, especially in those disciplines where enrolment is not controlled. It is assumed that employers will, on balance, continue to staff HQM occupations with graduates from related fields of study.

Community College Graduates

This is an important new factor on the HQM market. At the time of the 1971 Census and the 1973 HQMPS, the community colleges were still relatively new and the stock of graduates from these colleges was not extensive. As a consequence, the HQM Survey did not include such graduates.

While it was not possible, therefore, to explicitly take account of community college graduates in the model solution, the approach used is consistent with the concept and, given appropriate data, could provide this additional information.

The requirements for community college graduates arising out of the various HQM occupational and replacement demand changes are actually contained in the model solution, but in order to separate them as a category on their own, more information would be needed. As things stand now, the available information permits the separate identification of requirements for university graduates, as distinct from requirements for all other groups, including community college graduates.

As noted, the model methodology estimates the change in the proportion of required new entrants with university degrees, and then estimates the degree level and field of study of such entrants. This is done with the occupation/education matrix of probability coefficients. Given additional information, the appropriate vectors for the community college graduates could easily be added, which would then yield a model solution in which the requirements for such graduates are given separately.

Without this, however, they must, for the time being, remain part of the non-university-degree group. The proportion of persons without university degrees has traditionally been quite high in such HQM occupations as commerce, administration, management, government, etc., but there is evidence that this proportion is falling rapidly. These are also the HQM occupations in which the employment of community college graduates is most likely becoming much more prevalent. Of course, community college graduates find employment in the technical and professional support occupations as well, which are not defined, for purposes of this model, as HQM occupations.

SECTION 3

THE HQM PROJECTION MODEL

The outputs of this model are estimates of the demand for university graduates in occupations requiring a university degree. Such estimates are calculated by field of study. Various intermediate outputs are also generated in the process of solving the model, such as changes in HQM occupational stocks required in the economy in future years, estimates of changes in the age structure of the future HQM occupational stocks, and the replacement demands due to future attrition.

Most of the information on the basic HQM characteristics is cross-sectional rather than time series data. The most suitable method for the purpose of the project was found to be an input/output approach, but with some important additional features. The most interesting of these is the provision for changes, over time, in the coefficients of the various matrices and vectors relating to technological, behavioural and socio-demographic relationships. Changes in the coefficients can be introduced when new information becomes available, for purposes of policy simulation, or for sensitivity analysis.

A graphic outline of the model's elements and their major causal relationships are presented in Chart I. Involved in the solution process are the following:

- Population estimates by sex and single year of age, 1971-1985;

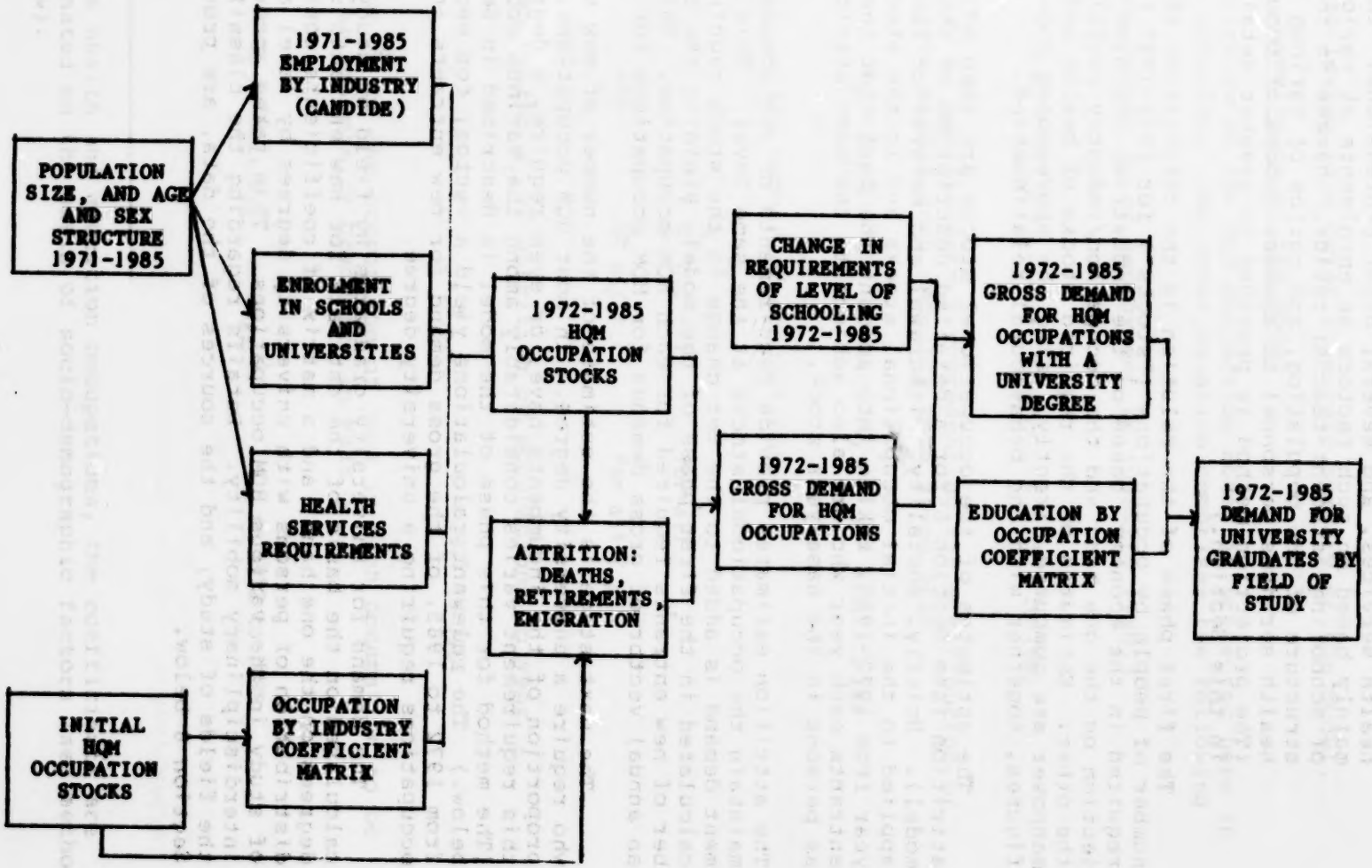
- Estimates of employment by industry, as defined by the Standard Industrial Classification (SIC), for the years 1971-1985. The employment projections are obtained with the aid of the CANDIDE econometric model (for a detailed description of the employment projections and the CANDIDE Model, see Section 4);

- The most up-to-date estimates available of the number of persons in the various HQM occupations by sex and single year of age, and by industry. The HQM occupations are those from the Occupation Classification Manual (OCM) which require a combined General Educational Development & Specific Vocational Preparation (GED/SVP) factor of at least 12. (Section 5 below describes the classification of the occupation data in greater detail);

- Technological relationships, describing the proportion of HQM functions in total employment, by industry (these are contained in the occupation by industry coefficient matrix). The coefficients can be varied when there is evidence of technological change that is quantifiable;

CHART I

HQM DEMAND PROJECTION MODEL


1971-1985 EMPLOYMENT BY INDUSTRY (CANDIDE)
POPULATION SIZE, AND AGE AND SEX STRUCTURE 1971-1985
ENROLMENT IN SCHOOLS AND UNIVERSITIES
HEALTH SERVICES REQUIREMENTS
INITIAL HQM OCCUPATION STOCKS
OCCUPATION BY INDUSTRY COEFFICIENT MATRIX
1972-1985 HQM OCCUPATION STOCKS
ATTRITION: DEATHS, RETIREMENTS, EMIGRATION
CHANGE IN REQUIREMENTS OF LEVEL OF SCHOOLING 1972-1985
1972-1985 GROSS DEMAND FOR HQM OCCUPATIONS
1972-1985 GROSS DEMAND FOR HQM OCCUPATIONS WITH A UNIVERSITY DEGREE
EDUCATION BY OCCUPATION COEFFICIENT MATRIX
1972-1985 DEMAND FOR UNIVERSITY GRAUDATES BY FIELD OF STUDY

- Behavioural relationships in the fields of education and health services, and several other professions. These are mainly based on such factors as enrolments at various levels of schooling, student-teacher ratios, changes in the age structure of the population, and ratios of various types of health services personnel to age-sex groups of population. (The projection method is provided in greater detail below, in this Section.)

The first phase of the solution is the calculation of the number of people by occupations ("stocks") for 1972-1985 that are required in the economy, based on the industrial employment projection on the one hand and the occupation/industry coefficients on the other. Estimates of the required stocks of health and education manpower are computed directly, using the above-noted population figures, together with the behavioural relationships.

The estimates of the occupational stocks are then adjusted for attrition (see Section 6 for a detailed description of the attrition model). Briefly, mortality, withdrawal and emigration factors are applied to the initial occupational stocks and to the stocks of each year from 1972-1985, taking into account the fact that there are new entrants each year who are also subject to the same attrition risks as persons in the base-year stock.

The attrition estimates provide requirements of replacements to maintain the occupational stocks at the same level. This replacement demand is added to the net change in the stock requirements calculated in the first phase of the model, yielding the total number of new entrants required for each HQM occupation. This produces an annual vector of gross demands for HQM occupations for 1972-1985.

The next stage is the estimate of the number of new entrants who require a university degree. In most HQM occupations, only a proportion of the incumbents have, or even require, a degree, and this requirement varies considerably among the various occupations. (The method for this phase of the model is described in Section 7 below.) The relevant calculations yield a vector, for each year from 1972 to 1985, of the gross demand for new entrants into HQM occupations requiring a university degree.

The demand for university graduates by field of study is then calculated on the basis of the estimate for new entrants requiring degrees on the one hand, and a matrix of coefficients containing the distribution of persons with university degrees by level and field of study in the various HQM occupations. This takes account of interdisciplinary mobility. Details regarding the classification of the fields of study, and the sources of the data, are provided in Section 8 below.

The following is a brief algebraic summary of the model.

Algebraic Formulation of the Model

An overview of the HQM projection model is presented here in algebraic notation. The model equation comprises the following components:

- a column vector e_t of employment by industry (IND) in year t

$$e_t = \{e_{1t}, e_{2t}, \ldots\ldots e_{IND,t}\} \qquad t = 1971 \text{ to } 1985$$

- a matrix[12] of coefficients P representing the distribution of occupations within each industry in a given year t

$$P_t = [p_{ij}] \qquad i = 1,2,\ldots, K; \quad j = 1,2,\ldots, IND$$

- where K is the number of occupations;

$$\sum_{i=1}^{K} pij = 1 \qquad \text{for all } j \text{ ,}$$

and $$0 \leq pij \leq 1 \qquad \text{for all } i,j$$

- a column vector a_t of attrition by occupations in year t

$$a_t = \{a_{1t}, a_{2t}, \ldots, a_{Kt}\} \qquad t = 1971 \text{ to } 1984$$

- a vector g_t of the proportion of jobs in each occupation to be filled by university graduates in year t

$$g_t = (g_{1t}, g_{2t}, \ldots\ldots, g_{Kt}) \qquad t = 1972 \text{ to } 1985$$

---

12 For the health and education occupations, the coefficients are estimated on the basis of socio-demographic factors (see method below).

- an array N representing the distribution of educational backgrounds, classified into the major fields of study and degree level within each occupation in a given year t

$$N_t = [n_{ijl}] \qquad i = 1,2,\ldots., K;\ j = 1,2,\ldots.,FOS$$
$$l = BA, MA, PHD.$$

- where FOS is the number of fields of study.

- The demand for university graduates by field of study in year t is thus written as

$$D_t = [P_t e_t - P_{t-1} e_{t-1} + a_{t-1}]' \; Z_t N_t$$

- where Z_t is a diagonal matrix of the vector g_t.

Method for Projecting Stocks of Health HQM

The demand for health manpower is expressed as a function of a given (current) level of health services, and the foreseeable changes in the composition of the population requiring such services. (Replacement requirements due to attrition are also estimated, as described in the attrition model in Section 6 below).

The demand for manpower within a given health occupation is assumed to be the sum of the manpower required in that occupation by the various age and sex groups that comprise the total population.

$$D_1^k + D_2^k \ldots. + D_n^k = D_{TOTAL}^k$$

where D_i^k = the manpower required in the k^{th} health occupation by the i^{th} age and sex group

$i = 1,2, \ldots., n.$

In the base year 0, the demand for manpower in a given health occupation k, within the i^{th} age and sex group, is defined as a function of some base year indicator of utilization (i.e. expenditures, average chairtime per person, etc...).

$$D^k_{i0} = b^k E_{i0}$$

where E_{i0} = the expenditure or degree of utilization of the i^{th} age and sex group in the base year 0.

b^k = constant for all $i = 1, 2, \ldots, n$.

The above n equations along with the constraint in the base year,

$$D^k_{10} + D^k_{20} + \ldots + D^k_{n0} = D^k_{n0} = D^k_{TOTAL,0}$$

(where $D^k_{TOTAL,0}$ is known) form a system of $n+1$ equations and n unknowns. This system is solved simultaneously to obtain D^k_{i0} for all i.

In order to derive estimates of the health manpower required to 1985, the ratio of manpower required in the k^{th} health occupation by the i^{th} age and sex group to the population of that group is assumed to remain constant to 1985:

$$\frac{D^k_{i0}}{P_{i0}} = R^k_i = \frac{D^k_{it}}{P_{it}} \qquad \text{for all } t \text{ to 1985}$$

Where P_{it} is the population of the i^{th} age and sex group in year t.

Thus the total manpower demanded in a given health occupation k, in a given year t is calculated in the following way:

$$D^k_{TOTAL,t} = \sum_{i=1}^{n} D^k_{it}$$

where $$\sum_{i=1}^{n} D^k_{it} = \sum_{i=1}^{n} R^k_i \cdot P_{it} \qquad i = 1, 2, \ldots, n$$

Projection of Teachers

The stocks of the various teaching occupations are a function of a given (current) level of service, as expressed in various student-teacher ratios, and of changes in enrolments. The latter are determined by changes in the composition of the population, and by the propensities of the various age cohorts to attend school.

The required stocks of university teachers to 1985 are based on estimates of the size and changing composition of the university-age population (i.e. the population 15 and over) to 1985, base year age-specific propensities to attend university and base year assumptions regarding the student-teacher ratio. The propensities to attend university by single years of age are derived from base year enrolments and an age distribution of enrolments obtained from the Post-Secondary Student Survey of 1975 for the following types of enrolments: undergraduate full-time, undergraduate part-time, graduate full-time and graduate part-time. Thus for each type of enrolment:

$$r_i = \frac{E_o d_i}{P_{oi}} \qquad i = 15, 16, 17 \ldots\ldots 50+$$

where r_i is the propensity of persons of age "i" to attend university

E_o is total enrolment in the base year 0,

d_i is the proportion of enrolments of persons of age "i",

and P_{oi} is the population of age "i" in the base period 0.

The propensities of the various age cohorts to attend university are assumed to be invariant over time.

Thus, university enrolment by type of program to 1985 is

$$E_t = \sum_i r_i P_{it} \qquad \text{for all } t \text{ to } 1985 \text{ and } i = 15, 16, \ldots\ldots 50+$$

Total enrolments are expressed in full-time equivalents on the basis of 3.75 part-time undergraduates for one full-time undergraduate and 2.5 part-time graduate for one full-time graduate.

The stock of university professors required to 1985 is related to these projected enrolments by means of the base year student-teacher ratio :

$$UT_t = S^{-1} E_t$$

where UT_t is the stock of university professors required in year t

and S is the base year student-teacher ratio.

The total stock requirements of university professors are broken down into the requirements by teaching speciality. (Distributions of professors by teaching speciality are available from the University Full-Time Teaching Staff System, which allows classification of professors into 71 teaching specialities[13], for the academic years since 1971-72).

The projections of post-secondary non-university enrolments are derived using base year enrolments and an age distribution of community college enrolments obtained from the Post-Secondary Student Survey of 1975. The required stocks of teachers are based on these enrolment projections and base year assumptions regarding the student-teacher ratio.

Stock requirements of preschool, Grades 1 - 8 and Grade 9 and over teachers are determined by the size of their respective age cohorts, the base year student-teacher ratio being held constant:

$$T_t = K^{-1} P_t$$

where T_t is the stock of teachers required in period t

K is the base year student-teacher ratio

and P_t is the population of the appropriate age cohort in the year t.

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13 See Table 5 under the occupation "University Teaching" for the list of the teaching specialities.

Other Professions

In a few professions, the underlying determinants of demand cannot be quite as clearly identified as in the categories of occupations described above. Lawyers, architects and veterinarians are the major examples of such professions, where the approach in estimating demand is more arbitrary and pragmatic. The demand for architects is related to the growth of employment in the construction industry, while the demand for lawyers is linked to the growth of the adult population. Similarly, the demand for the services of veterinarians is tied to demographic factors.

The replacement demand for such independently derived forecasts is also calculated by the general attrition model described in Section 6.

SECTION 4

EMPLOYMENT - PROJECTION METHOD

Industry Classification

A framework of disaggregated estimates of industrial employment was chosen because it permits a more concise assessment of the occupational developments. One important element in the demand for HQM is the change in the industrial structure of the economy. It is therefore an advantage, when projecting HQM demands, to use the finest level of detail possible in estimating future industrial employment trends.

The HQM projection model uses the industrial disaggregation provided in CANDIDE, the econometric model that is used for the employment projections (see below), with some further breakdown of manufacturing and public administration. The CANDIDE employment estimates for manufacturing are split into durable and non-durable manufacturing; those for the service industries are divided into education, health and welfare, services to management, and other services; and those for public administration are split into federal government and all other public administration. In particular, manufacturing employment, as provided by the Labour Force Survey up to 1975, and as estimated to 1985 by CANDIDE, was split by using the actual Labour Force Survey data on durable/non-durable employment to 1975, and holding the 1975 ratio constant to 1985. Employment in the service industry was divided according to actual Labour Force Survey data to 1975. From 1975 on, the employment shares of the education and health sectors are based on socio-demographic factors, while the shares for the other two sectors are derived residually. The public administration employment was split by using actual Statistics Canada employment data to 1975, and assuming a growth rate for federal public administration employment of one per cent per year for the projection period. The growth of employment in non-federal public administration is derived residually.

Table 1 provides the SIC categories used in the HQM projection model.

Econometric Employment Projections by Industry

Projections of employment by industry are obtained from the CANDIDE model[14]. CANDIDE is a large econometric model designed

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14 For a complete discussion of the model, see M.C. McCracken, An Overview of CANDIDE Model 1.0, CANDIDE Project Paper No. 1, published by Economic Council of Canada for the Interdepartmental Committee of CANDIDE, Information Canada, Ottawa, 1973. (There are 15 detailed studies dealing with various aspects of the CANDIDE Model.) See also: CANDIDE Model 1.1, Project Paper No. 18, edited by R. Bodkin and S. Tanny, Economic Council of Canada, 1975.

TABLE 1

HQM PROJECTION MODEL - INDUSTRIAL DISAGGREGATION OF EMPLOYMENT

SIC DIVISION	SIC MAJOR GROUPS	INDUSTRY
1	All	Agriculture
2	All	Forestry
3	All	Fishing and Trapping
4	All	Mines (including Milling) Quarries and Oil Wells
5	8,9,12,13,14,15,16,17	Durable Manufacturing
5	1,2,3,4,5,6,7,10,11, 18,19,20	Non-durable Manufacturing
6	All	Construction
7	4	Utilities (Electric, Gas, Water)
7	1,2,3	Transportation and Communication
8	All	Trade
9	All	Finance, Insurance and Real Estate
10	1	Education
10	2	Health and Welfare
10	5	Services to Business Management
10	4,5,6,7,8	Other Services
11	1	Federal Administration and Defence
11	2,3,4	Other Public Administration

to project annual values over the medium-term horizon. It is a general purpose model that represents most of the major aggregates shown by Statistics Canada in their publications and used by government departments for policy analysis. Due to its general purpose orientation and the inclusion of some industrial detail, CANDIDE is much larger than most econometric models. Currently, it contains some 2,050 equations, of which 616 are stochastic. The remaining equations are identities, of which some 427 are used to incorporate the input/output sub-models. There are 450 exogenous variables.

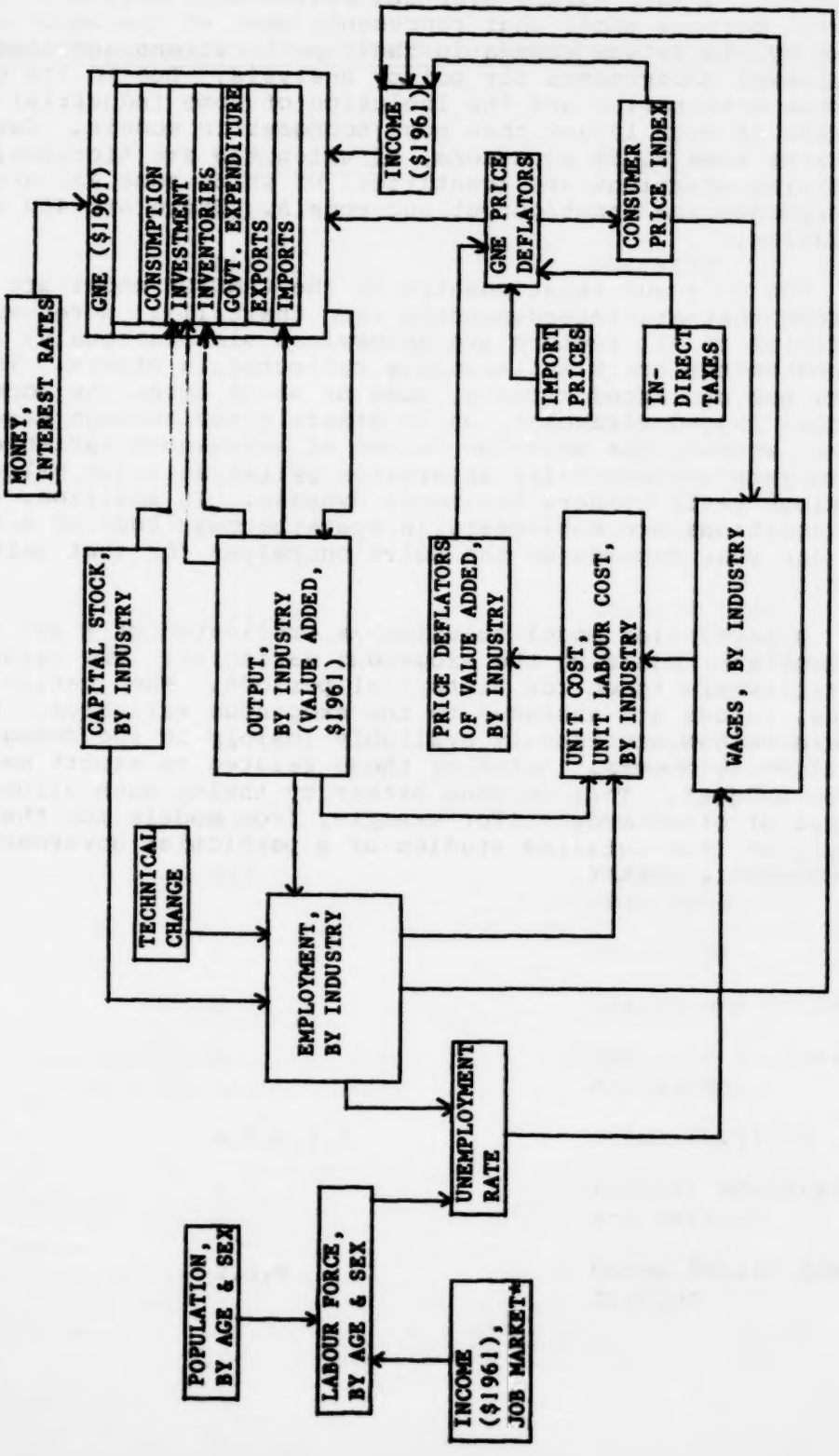
The data and relationships in the CANDIDE model are arranged in sectors that are interdependent (see Chart II). Moreover, the variables in all sectors are determined simultaneously; i.e. changes in one sector are simultaneously reflected in others. The model makes use of lagged effects, some of which enter the model directly through lagged variables, while others enter through stocks. The effect whereby the solution values of endogenous variables in a given year are partially determined by the solution values of previous years renders the model dynamic. In addition, a number of the equations are nonlinear, in that the magnitude of a change in any one year depends on the solution values for that particular year.

A particular model solution is predicated on a set of basic assumptions regarding the exogenous variables. The values of these variables are known for historical periods. When making projections, values are assigned to the exogenous variables. While some future values are readily available (mainly in the demographic area), most others, including those related to export markets, have to be assumed. This is done either by taking such values from the output of other models (for example, from models for the U.S. economy), or from detailed studies of a particular government program or commodity market.

CHART II

CANDIDE MODEL

MAJOR DETERMINANTS OF THE INDUSTRIAL STRUCTURE



SECTION 5

OCCUPATIONS - DEFINITION AND CLASSIFICATION

The occupational definitions used in this projection model are based on the Canadian Classification and Dictionary of Occupations (CCDO) and the 1971 Occupational Classification Manual (OCM)[15] that was used for the 1971 Census and the HQMPS.

The CCDO structure encompasses 23 major groups (specified by a 2-digit code) which are the highest level of aggregation of occupations and represent broad fields of work rather than specific types of work performed. These major groups are sub-divided into 81 minor groups (designated by a 3-digit code) which are in turn disaggregated into 498 unit groups (represented by a 4-digit code). The narrowest categories specified in the CCDO classification system are the individual occupations; they are listed by a 7-digit code and encompass over 25,000 occupational titles.

A unique feature of this classification system which distinguishes it from previous census classifications is the delineation of the educational and vocational training required within each 7-digit occupational group. In particular, the descriptions of each of the 7-digit occupations also include indices of their requirements in the form of "General Educational Development" (GED) and "Specific Vocational Preparation" (SVP). These indices help define those occupational groups which require a university degree.

Each 7-digit occupation is assigned a General Educational Development index (GED) which "... embraces those aspects of education (formal and informal) which contribute to the worker's (a) reasoning development and ability to follow instructions, and (b) acquisition of 'tool' knowledges, such as mathematical and language skills. GED refers to education of a general nature which does not have a recognized, specific occupational objective.

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15 Although Statistics Canada has provided data on occupations via the census mechanism since 1931, the CCDO represents the first attempt to define the qualification required for each occupational group. For an excellent summary of the intercensal occupational definitions, see "Establishing Comparable Census Occupations for Historical Comparisons of Earnings and Other Data" by N.H. Meltz and D.A.A. Stager, Centre for Industrial Relations, University of Toronto, August 12, 1976.

Ordinarily, such education is obtained in elementary school, high school, or college; however it is derived also from experience and self-study"[16].

A different interpretation of GED levels in terms of years of schooling is shown in Table 2.

TABLE 2

LEVELS OF GENERAL EDUCATIONAL DEVELOPMENT, CCDO

Levels	Approximate Duration of Schooling
6	17 years plus
5	13 to 16 years
4	11 to 12 years
3	9 to 10 years
2	7 to 8 years

SOURCE: Department of Manpower and Immigration, CCDO, Vol. 2, p. XV.

The Specific Vocational Preparation (SVP) index pertaining to each occupation is: "... measured by the amount of time needed to acquire the information, techniques, and skills needed for average work performance in a specific occupation. This training may be acquired in a school, work, military, or institutional environment, or through vocationally-oriented hobbies. It does not include orientation training required of a worker to become accustomed to the special conditions of a new job for which he is already fully qualified"[17].

Such SVP includes training given in any of the following forms: (a) university or college training where the average four-year university or college curriculum is considered as equivalent

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16 Department of Manpower and Immigration, Canadian Classification and Dictionary of Occupations, (henceforth referred to as the CCDO), Vol. 1, Appendix A, p. 1161. For a discussion concerning reading, mathematical and language requirements see P. 1162.

17 Department of Manpower and Immigration, CCDO, Vol. 1, p. 1163.

to about two years of specific vocational preparation; (b) vocational training; (c) apprenticeship; (d) in-plant training; (e) on-the-job training; and (f) experience in other jobs. The various levels of SVP are shown in Table 3.

The GED and SVP indices provide the basis for defining a highly qualified manpower occupation. The model's estimates are at the 4-digit occupational level, since the 1971 Census does not provide the necessary tabulations for more disaggregated groupings of occupations. For this reason, the GED/SVP levels for the 4-digit groups are the averages of the levels pertaining to the 7-digit job titles, as provided in the CCDO.

TABLE 3

LEVELS OF SPECIFIC VOCATIONAL PREPARATION - CCDO

Level	Period of Preparation
1	Short demonstration only
2	Anything beyond short demonstration up to and including 30 days
3	Over 30 days up to and including 3 months
4	Over 3 months up to and including 6 months
5	Over 6 months up to and including 1 year
6	Over 1 year up to and including 2 years
7	Over 2 years up to and including 4 years
8	Over 4 years up to and including 10 years
9	Over 10 years

SOURCE: Department of Manpower and Immigration, CCDO, Vol. 1, Appendix A, Sec. II, p. 1163.

Table 4 shows the average levels of GED/SVP for 4-digit occupational groups, and the number of 7-digit occupational groups contained in each 4-digit group.

It should be noted that the CCDO occupational titles and code numbers were used only as a framework for the Occupational Classification Manual (OCM) and the two systems are quite different in many respects[18]. For this reason, the 4-digit occupations used here refer to the OCM and not the CCDO occupational classes. In order to prepare the listing in Table 4 each CCDO occupation was examined to assure consistency, since the 1971 Census data are based on the OCM. In cases where the GED/SVP was not provided in the CCDO, estimates were made as to whether or not the occupation in question should be classified as HQM. Those occupations with an average GED/SVP of less than 12 were also examined to determine their possible HQM content. For example, elementary and preschool teachers were classified as HQM, although the average GED/SVP was only 11. Because of educational upgrading, all future elementary and preschool teachers require a degree.

The generally accepted definition for an HQM occupation is a GED/SVP index of 12 or higher. Table 5 shows the grouping of all HQM occupations, classified in such a way that the data can be linked with employment by industry on the one hand and field of study on the other.

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18 The document entitled "Classification Discrepancies Between the 1971 Occupational Classification Manual (OCM) and the 1971 Canadian Classification and Dictionary of Occupations (CCDO)" which was prepared for the seminar on Occupational Research, Statistics Canada, March, 1976, discusses the major differences between the two manuals.

TABLE 4

LIST OF 4-DIGIT OCCUPATIONS,
WITH AVERAGE GED/SVP LEVELS AND NUMBER OF 7-DIGIT GROUPS

Aggregate Occupation	OCM No.	4-Digit Occupations	CCDO GED/SVP Average	Number of 7-Digit CCDO Groups
HEALTH	3113	Dentistry	14	7
	3111	Medicine	15	18
	3151	Pharmacist	13	3
	3130	Nursing, Supervisors	12	1
	3131	Nursing, Graduate	12	10
	3137	Rehabilitation Therapists	12	4
	1134	Health Administration	12	7
	3117	Osteopaths & Chiropractors	12	2
	3119	Health Diagnosing	12	2
	3153	Optometrists	12	1
	3133[1]	Nurses-in-Training	-	-
	3134	Nursing Assistants	8	1
	3135	Nursing Aides and Orderlies	7	2
	3139	Nursing, Therapy and Related Assisting Occupations, n.e.s.	8	7
	3154	Dispensing Opticians	10	1
	3155	Radiological Technologists and Technicians	11	3
	3156	Medical Laboratory Technologists and Technicians	11	7
	3157	Dental Hygienists, Assistant and Technicians	9	19
	3159	Other Occupations in Medicine and Health, n.e.s.	8	16
ENGINEERING	2141	Architecture	14	2
	2142	Chemical Engineering	14	2
	2143	Civil Engineering	14	13
	2144	Electrical Engineering	13	12
	2147	Mechanical Engineering	13	9
	2151	Metallurgical Engineering	13	1

[1] See notes at end of Table 4.

TABLE 4 (cont'd)

LIST OF 4-DIGIT OCCUPATIONS,
WITH AVERAGE GED/SVP LEVELS AND NUMBER OF 7-DIGIT GROUPS

Aggregate Occupation	OCM No.	4-Digit Occupations	CCDO GED/SVP Average	Number of 7-Digit CCDO Groups
ENGINEERING (cont'd)	2155	Aeronautical Engineering	13	7
	2153	Mining Engineering	13	1
	2154	Petroleum Engineering	13	3
	2145	Industrial Engineering	13	8
	2157	Nuclear Engineering	14	1
	2159	Architects & Engineers, n.e.s.	13	13
	2160[1]	Supvrs. Other Eng. & Arch.	-	3
	2161	Surveyors	11	4
	2163	Draughtsmen	10	20
	2165	Architectural and Engineering Technologists and Technicians	11	14
	2169	Other Occupations in Architecture and Engineering, n.e.s.	11	6
LIFE SCIENCES	3115	Veterinary Medicine	14	1
	3152	Dietetics and Nutrition	12	5
	2131	Agriculture and Related	14	7
	2133	Biology and Related	14	26
	2135	Life Science Technologists and Technicians	10	14
	2139[2]	Occupations in Life Sciences n.e.s.	14	2
PHYSICAL SCIENCE & MATH	2112	Geology	14	8
	2114	Meteorology	14	1
	2111	Chemistry	14	7
	2113	Physics	14	15
	2181	Mathematicians, Statisticians, Act.	13	12
	2189	Occs. in Math, Stats., System Anal.	12	2

[1,2] See notes at end of Table 4.

TABLE 4 (cont'd)

LIST OF 4-DIGIT OCCUPATIONS,
WITH AVERAGE GED/SVP LEVELS AND NUMBER OF 7-DIGIT GROUPS

Aggregate Occupation	OCM No.	4-Digit Occupations	CCDO GED/SVP Average	Number of 7-Digit CCDO Groups
PHYSICAL SCIENCE & MATH (cont'd)	2183	Computer Programming and Related	12	6
	2117	Physical Sciences Technologists and Technicians	10	18
	2119	Occupations in Physical Sciences, n.e.s.	11	5
HUMANITIES & FINE ARTS	2511	Ministers of Religion	14	2
	2513[3]	Nuns and Brothers	-	-
	2519	Occs. in Religion, n.e.s.	13	3
	2350	Supvrs. Library, Museum & Arch. Sc.	13	4
	2351	Librarians & Archivists	12	6
	3355	Translation	12	4
	3311	Painters, Sculptors, Artists	12	4
	3313	Product & Interior Design	12	21
	3314	Advertising & Illustration Artists	12	10
	3330	Producers and Directors, Arts	13	14
	3332	Musicians	12	11
	3333	Choreographers and Dancers	12	2
	3352[4]	Writers and Editors	12	7
	3315	Photographers and Cameramen	10	15
	3319	Occupations in Fine and Commercial Art, Photography and Related Fields, n.e.s.	8	23
	3335	Actors	11	5
	3337	Radio and Television Announcers	11	6
	3339	Occupations in Performing and Audiovisual Arts, n.e.s.	9	21

[3],[4] See notes at end of Table 4.

TABLE 4 (cont'd)

LIST OF 4-DIGIT OCCUPATIONS,
WITH AVERAGE GED/SVP LEVELS AND NUMBER OF 7-DIGIT GROUPS

Aggregate Occupation	OCM No.	4-Digit Occupations	CCDO GED/SVP Average	Number of 7-Digit CCDO Groups
HUMANITIES & FINE ARTS (cont'd)	3359	Occupations in Writing, n.e.s.	9	5
	3370	Coaches, Trainers, Instructors, & Managers, Sport & Recreation	10	16
	3371[4]	Referees & Related Officials	8	15
	3373[4]	Athletes	9	4
	3375[4]	Attendants, Sport and Recreation	6	17
	3379[4]	Others in Sport and Recreation, n.e.s.	8	6
	2353	Technicians in Library, Museum and Archival Sciences	11	7
	2359[2]	Occupations in Library, Museum and Archival Sciences, n.e.s.	12	3
EDUCATION	2711	University Teachers	14	12
	2731[5]	Elementary and Preschool	11	3
	2733	Secondary School Teachers	12	2
	2739[1,5]	Other Elementary and Secondary	-	1
	2391	Counselling and Guidance	13	4
	2795	Spec. Educ. Excep. Children	12	5
	1133	Education Administrators	13	9
	2791	Community Coll. & Voc. Teachers	12	6
	2792	Fine Arts Teachers	12	5
	2793	Post-Secondary Teachers, n.e.s.	13	3
	2719	University Teachers and Related n.e.s.	12	2
	2797	Instructors and Training Officers, n.e.s.	11	11

[1,2,4,5] See notes at end of Table 4.

TABLE 4 (cont'd)

LIST OF 4-DIGIT OCCUPATIONS,
WITH AVERAGE GED/SVP LEVELS AND NUMBER OF 7-DIGIT GROUPS

Aggregate Occupation	OCM No.	4-Digit Occupations	CCDO GED/SVP Average	Number of 7-Digit CCDO Groups
EDUCATION (cont'd)	2799	Other Teaching and Related Occupations, n.e.s.	10	7
LAW	2341	Judges and Magistrates	15	1
	2343	Lawyers and Notaries	13	3
COMMERCE, ADMINISTRATION, GOVERNMENT	1111	Members Legislative Bodies	-	3
	1113	Government Administration	13	6
	1115	Postmasters	12	2
	1116	Inspectors & Reg. Off. Gov't	11	16
	1119	Officials & Admin. Unique to Gov't	11	24
	1130	Gen. Mgrs. & Other Sr. Officials	14	10
	1131	Mgt. Occs. Nat. Sc. & Eng.	13	6
	1132	Mgt. Occs. Soc. Sc. & Rel.	13	4
	1135	Financial Mgt. Occs.	13	6
	1136	Personnel and Ind. Rel. Mgt. Occs.	13	2
	1137	Sales & Advertising Mgt. Occs.	13	4
	1141	Purchasing Mgt. Occs.	12	2
	1142	Service Mgt. Occs.	12	6
	1143	Production Mgt. Occs.	13	3
	1145	Mgt. Occs. Const. Oper.	13	2
	1147	Mgt. Occ. Trans. & Comm.	13	13
	1149	Other Mgrs. & Admin., n.e.s.	13	11
	1174	Personnel and Rel. Off.	12	7
	1175	Purchasing Off. & Buyers & Trade	12	4
	1176	Inspectors & Rel. Off. Non Gov't	10	15
	1179	Occs. Rel. to Mgt. & Admin.	11	18
	1171	Accounting	12	21
	5131	Technical Sales	12	12
	5170	Super. Sales & Serv.	11	5

TABLE 4 (concl'd)

LIST OF 4-DIGIT OCCUPATIONS,
WITH AVERAGE GED/SVP LEVELS AND NUMBER OF 7-DIGIT GROUPS

Aggregate Occupation	OCM No.	4-Digit Occupations	CCDO GED/SVP Average	Number of 7-Digit CCDO Groups
COMMERCE, ADMINISTRATION, GOVERNMENT (cont'd)	6116[1]	Commissioned Officers	-	-
	7131	Farm Management	11	3
SOCIAL SCIENCES	2331	Social Work	13	6
	2399	Other Occs. Soc. Sc. & Rel., n.e.s.	12	4
	2351	Psychologists	14	11
	2311	Economists	14	13
	2313	Sociologists, Anthropologists and Related	14	2
	2319	Occs. Soc. Sc., n.e.s.	13	7
	2333	Occs. in Welfare and Community Services	10	5
	2339	Occs. in Social Work and Related Fields, n.e.s.	8	3
	2349	Occs. in Law and Jurisprudence, n.e.s.	11	8

1 See notes at end of Table 4.

NOTES

1. No GED/SVP were provided for these groups.

2. The 7-digit occupations classified in the CCDO were not equivalent to the 7-digit occupations in the OCM. For these groups, the occupations defined in the OCM were designated as non-HQM.

3. These groups were not classified in the CCDO but were contained in OCM.

4. These occupations were classified as 3353, 3710, 3711, 3713, 3715, 3719 in the CCDO, but 3352, 3370, 3371, 3373, 3375, 3379 in OCM respectively.

5. These groups were defined as HQM becuse of institutional requirements.

SOURCE: Department of Manpower and Immigration, CCDO, Vol. 1, and DBS, Occupational Classification Manual, (prepared for the 1971 Census).

TABLE 5

HQM PROJECTION MODEL - CLASSIFICATION OF HQM OCCUPATIONS

MAJOR GROUP	OCM NUMBER	OCCUPATION
Health	3113	Dentistry
	3111	Medicine
	3151	Pharmacy
	3130-31	Nursing
	3137	Rehabilitation Therapy
	1134	Health Administration
	3117-19-53	Other HQM Health
Engineering	2141	Architecture
	2142	Chemical Engineering
	2143	Civil Engineering
	2144	Electrical Engineering
	2147	Mechanical Engineering
	2151	Metallurgical Engineering
	2155	Aeronautical Engineering
	2153	Mining Engineering
	2154	Petroleum Engineering
	2145	Industrial Engineering
	2157-59	Engineering n.e.s.
Life Sciences	3115	Veterinary Medicine
	3152	Dietetics and Nutrition
	2131	Agriculture and Related
	2133	Biology and Related
Physical Sciences and Mathematics	2112	Geology
	2114	Meteorology
	2111	Chemistry
	2113	Physics
	2181-89	Mathematics
	2183	Computer Sciences
Humanities and Fine Arts	2511-13-19	Religion
	2350-51	Library and Archival
	3355	Translation
	3311-13-14-30-32-33-52	Other HQM Humanities and Fine Arts
Education	2711	University Teaching
		Dentistry
		Medicine
		Pharmacy
		Nursing
		Rehab. Therapy
		Health Adm. & Other
		Medical Research
		Architecture
		Chemical Engineering

TABLE 5 (cont'd)

HQM PROJECTION MODEL - CLASSIFICATION OF HQM OCCUPATIONS

MAJOR GROUP	OCM NUMBER	OCCUPATION
Education (cont'd)		Civil Engineering
		Electrical Engineering
		Mech., Aero. Engineering
		Metall. Engineering
		Mine., Geol. Engineering
		Indust. & Other Engineering
		Agric. Engineering
		Veterinary Medicine
		Dietetics
		Agriculture
		Forestry
		Biochemistry
		Biology
		Botany
		Zoology
		Household Sci.
		Agric., Bio. Sci.
		Geol., Meteor., Ocean.
		Chemistry
		Physics
		Mathematics
		Computer Sciences
		Metallurgy
		Other Math., Phys.
		Theology
		Library, Archiv.
		Translation
		Fine, Applied Arts
		History
		English
		French
		Mod. Languages
		Classics, Philos.
		Other Humanities
		Secondary School Teaching
		Elementary School Teaching
		Education Admin.
		Counselling
		Special Education
		Other Teaching
		Educ. Psychology
		Other Non-teaching Ed.
		Education, Other
		Law
		Accounting
		Commerce, Admin.
		Social Work
		Clinical Psych.

TABLE 5 (concl'd)

HQM PROJECTION MODEL - CLASSIFICATION OF HQM OCCUPATIONS

MAJOR GROUP	OCM NUMBER	OCCUPATION
Education (cont'd)		Psychology (Other)
		Economics
		Anthrop., Archaeol.
		Geography, Env. Stud.
		Pol. Sci.
		Sociol., Demog., Crimin.
		Linguistics
		Other Soc. Sciences
	2731	Elementary and Preschool
	2733	Secondary School
	2791	Community College Teaching
	2719-39-92 93-95 and 2391 and 1133	Other HQM Education
Law	2341-43	Law
Commerce, Administration and Government	1111-13-15-16-19	Government Officials and Administrators
	6116	Commissioned Officers
	1130-31-32-35 36-37-41-42-43-45-47-49	General Administration
	1174-75-76-79	Related Management Occupations
	1171	Accounting
	5131	Technical Sales
	5170	Supervising - Sales and Services
	5173	Sales, Securities
	7131	Farm Management
Social Sciences	2331-99	Social Work
	2315	Psychology
	2311	Economics
	2313	Sociology, Anthropology and Related
	2319	Other Social Sciences and Related n.e.s.

SECTION 6

ATTRITION ESTIMATES

The Attrition Model

The attrition model generates estimates of the replacement demand for highly qualified manpower by taking perpetual inventory of the stocks by age, sex and occupation and subjecting them to the risks of attrition - mortality, retirement and emigration. The inventory is based on the age and sex distribution of employment within each HQM occupation in the base year and assumptions pertaining to mortality rates, emigration, retirement rates and the age-sex distribution of new entrants. This section describes both the underlying assumptions and the method involved in the calculation of the demand due to attrition.

The analysis is carried out at an extremely fine level of detail, with regard to the number of occupations, and the age-sex composition by single years of age. For this reason, all input data files are obtained in machine-readable form, directly from the various survey sources. Base-year information on the number of persons in most occupations other than those in the health and education fields are from the 1971 Census. The health and education numbers are obtained from Statistics Canada administrative records, not only for the base-year (usually 1971) but also for more recent years. The number, and distribution by specialization, of university professors is from the Statistics Canada "University Full-Time Teaching Staff System Manual".

The information on the base year age-sex distribution for most occupations is obtained from the 1971 Census, while the distribution for university teachers, relating to the year 1975, is from the above mentioned university files of Statistics Canada.

Basic Assumptions

Mortality assumptions are based on the most recent information available, and relate to single-year age-sex groups. One set of mortality rates serves for all occupations, and the rates are the same for all years to 1985. This is a common type of assumption in recent demographic studies, since there appears to have been relatively little change in recent mortality behaviour to warrant different assumptions. Not enough information is available to ascertain whether death rates for the various HQM occupations differ significantly from each other.

The overall level of emigration to all countries is assumed to be 80,000 a year, for each year to 1985. The emigration from HQM occupations, included in the total, is estimated by reference to U.S. immigration records and taken to be approximately 10,000 a year. The distribution by occupation and sex of the emigrants from the HQM occupations is assumed to be the same as that of the

Canadian labour force in 1971. The age distribution of emigrants is based on a recent study by Statistics Canada[19]. A lower age bound of 25 years is assumed for emigrants leaving HQM occupations. These assumptions are held constant over the projection period.

Age, sex and occupation-specific net withdrawal rates for 10 male and 4 female occupational groups are derived for those aged 55 and over, using a method similar to that by which the tables of working life are calculated. The 1971 Census provides stock estimates by single years of age, sex and occupation. For each occupation group "participation rates" by single years of age and sex are calculated by standardizing the 1971 stock numbers to the 1971 population by single years of age and sex. These rates are applied to the respective age and sex groups of a stationary population[20] to obtain the number of persons from a specific cohort who are in a given occupational group at each successive age. The difference in the stock of age i and the stock of age $i + 1$ in a given occupation is assumed to be due to the effects of mortality, retirement and emigration:

$$S^k_{i+1,\ j,\ t+1} = S_{ijt}\ (1 - d_{ij})(1 - r^k_{ij}) - E^k_{ij}$$

Given the stock estimates derived from the "participation rates" and the stationary population, the above equation can be solved for r^k_{ij}, withdrawal rate. The withdrawal rates are held constant to 1985[21].

The total number of new entrants into an occupation each year is the sum of (a) the growth in the required stock of persons; and (b) the demand for replacements due to the various types of attrition noted above. The age-sex distribution of such new entrants into each HQM occupation is based on the HQM Post-Censal Survey.

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19 Statistics Canada, Technical Report on Population Projections for Canada and the Provinces, 1972-2001, Cat. No. 91-516, p. 218; and Statistics Canada, 1971 Census, Occupation by Sex and Age, Cat. No. 94-723.

20 The stationary population comprises the number of persons who will be alive and in Canada at different ages out of an original group of 100,000 born alive. In practice, two stationary populations are calculated - one for males and one for females. They are computed using mortality rates and emigration estimates consistent with the assumptions of the attrition model.

21 See next page for an explanation of the symbols.

Method

The existing stocks in the base period 0 are subjected to the risks of mortality, withdrawal and emigration which are appropriate to their age, sex and occupation.

The decrease this causes in the overall stock level by occupation is the demand due to attrition at the beginning of period 1. Algebraically this can be expressed in the following way:

$$D^k_{R_1} = \sum_i \sum_j S^k_{ijo} (d_{ij})(r_{ij}{}^k) + E^k_{ij}$$

where $D^k_{R_1}$ is the replacement demand in the k^{th} occupation in period 1

S^k_{ijo} is the stock in the k^{th} occupation of age i and sex j in the base period 0

d_{ij} represents the mortality rate of persons of age i and sex j

r^k_{ij} is the withdrawal rate of persons in the kth occupation of age i and sex j

E^k_{ij} is the number of emigrants from the k^{th} occupation of age i and sex j.

The new entrants by single years of age, sex and occupation in period 1 are added to the age, sex and occupation-specific stocks remaining from period 0. These new stocks are, in turn, subjected to the various risks of attrition, producing estimates of replacement demanded by each occupation in period 2. The process is reiterated to the end of the projection period.

SECTION 7

UNIVERSITY DEGREE REQUIREMENTS FOR NEW ENTRANTS

An analysis of Census data shows, among other things, that not all HQM jobs are filled with university graduates, and that the proportion of HQM jobs in a given occupational class which is filled by university graduates is changing. Naturally, the demand for university graduates is sensitive to the magnitude and direction of these changes. For simulation purposes three variants are posited: (1) the percentage of persons with a university degree in a given HQM occupation is held constant at the 1971 level; (2) all HQM jobs becoming available over the projection period are assumed to be filled by university graduates; and, (3) the proportion of jobs filled by university graduates is raised, either by assuming it to be fixed higher than the 1971 level, or by allowing it to rise gradually over the projection period.

Rising trends in such proportions are calculated on the basis of data from the 1971 Census using a quasi-longitudinal approach. In particular, the percentage of university graduates in the 25-34 age group in a given occupation is assumed to be representative of the degree/non-degree composition of new entrants in 1971, and the percentage of university graduates in the 35-44 age group is assumed to be indicative of the composition of new entrants in 1961.

For the purpose of determining the degree/non-degree composition of new entrants, the HQM occupations are divided into four categories. The first consists of those HQM occupations in which it is assumed that, because of regulated entry into the professions and strict educational requirements, all or a constant proportion of available jobs are filled by university graduates. These occupations are assigned constant coefficients to 1985. The second category consists of all HQM occupations in which the percentage of jobs filled by university graduates from the 25-34 age group was found to be lower than that for the 35-44 age group. In the absence of any data to indicate a continued decline or an eventual increase, the coefficients for these occupations are assumed to remain constant at the 1971 level up to 1985. The third category consists of those HQM occupations in which the percentage of university graduates from the 25-34 age group was found to be higher than the percentage for the 35-44 age group. In these occupations it is assumed that the proportion of university graduates will increase as a function of time. Logit equations, which approximate an "S" shaped curve, are used to derive the coefficients. The fourth category comprises all non-HQM jobs as well as the residual group "All other OCM codes". The percentage of university graduates employed in these occupations is not an indication of a demand for university trained personnel, since these occupations have a GED/SVP of less than that required for HQM occupations. They were assigned coefficients of zero.

SECTION 8

FIELD OF STUDY - DATA SOURCE AND CLASSIFICATION

Data Source

Unlike the numerous potential sources of data concerning occupations, there is only one source which provides estimates of the stock of university graduates classified on the basis of educational specialty. This is the Highly Qualified Manpower Post-Censal Survey (HQMPS) which was carried out in September of 1973 by Statistics Canada, in cooperation with the Ministry of State for Science and Technology[22]. From this Survey, the Ministry was able to obtain the 1973 estimates of the educational qualifications of those graduates who reported a university degree in the 1971 Census. This Survey does not provide a complete picture of university trained manpower in 1973, since it excludes those persons who received undergraduate degrees between June 1, 1971 and September of 1973, and those persons who died, emigrated or immigrated during this time period. Also, it does not include those persons who were not classified as permanent residents on June 1st, 1971.

Classification

Table 6 provides a detailed specification of the 92 fields of study classifications which are available from the HQMPS. These 92 fields were rearranged into the disciplinary groups shown in Table 7 to generate a list of disciplines which display the best possible match with the HQM occupational groups defined in Section 5. These sub-groups were further aggregated into the fields of specialization shown in Column 1, Table 7.

The Occupation by Education Arrays

The tables are based on the tabulation of the number of persons in a given occupation by level and type of university degree. Depending on requirements, such tables of coefficients can show the distribution of degree holders in a given field of study by degree level for the various occupations, or the distribution of the incumbents in a given occupation by level and type of degree. The latter kind of array is used in the projection model to estimate the demand for university graduates by level and field of study, based on occupational projections (See Section 3). Two arrays are constructed - one for all HQM occupations except university teaching

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[22] Copies of the Survey Methodology and data tapes can be obtained from the Education, Science and Culture Division of Statistics Canada.

and a second for university professors in whose case occupations are defined as teaching specialities. The definition of these arrays is derived from the classification of occupations in Table 5, and the field of study classification in Table 7.

For the majority of the occupations in the first array, the distributions by field of study and degree level are derived from the 1973 HQMPS. However, for occupations in which there are mandatory requirements including education, the field of study distributions are restricted to those fields which are considered relevant with the distributions by degree level remaining as reported in the 1973 HQMPS. In both cases, the reference population is the labour force under the age of 35 in 1971. The under 35 group is selected because it was felt to be more representative of new entrants than the total population. However, in certain occupations (notably those dealing with administration) where experience is an important factor in securing and holding the position, the total HQM population is used as the reference group. The field of study is defined as that of the last highest degree obtained by 1971.

The occupation by education array for university professors is deduced from two distributions: the 1975 field of teaching distribution for university professors obtained from the University Full-Time Teaching Staff System Manual of Statistics Canada, and the 1973 field of study for all university professors from the HQMPS data base. The distribution of new entrants into the university teaching profession by degree level is determined by estimating the total attrition by field of specialty and degree level over the period 1971-72 to 1974-75, and comparing this with the total change in stocks over the same period. The distribution of new entrants by degree level over the years 1971-72 to 1974-75 is assumed to be invariant over the projection period.

TABLE 6

HIGHLY QUALIFIED MANPOWER POST-CENSAL SURVEY

FIELD OF STUDY CLASSIFICATION

CODE[1]	FIELD OF STUDY	CODE[2]
0	General Arts - No Major Field	00
1	Elementary and Preschool Education	01
2	Special Education for Exceptional Children	02
3	Physical Education, Recreation and Related	03
4	Teaching Art, Commerce, Vocational Subjects	04
5	Secondary Education	05
6	Teaching Fields, n.e.s.	06
7	Counselling and Guidance in Schools	07
8	Education Administration and Organization	08
9	Educational Psychology	09
10	Education in General	10
11	Other Non-Teaching Fields Related to Education	11
12	Fine and Applied Arts	12,14
13	Music	13
15	Classics and Classical Languages	15
16	History	16
17	Library and Archival Sciences	17
18	English	18
19	French	19
20	Other Modern Languages and Literature	20
21	Philosophy	21
22	Theology and Religion	22
23	Translation and Interpretation	23
24	Journalism, Creative Writing, Humanities, n.e.s.	24
25	Institutional Admin. (Except School and Health)	25
26	Agricultural Economics	26
27	Anthropology	27
28	Archaeology	28
29	Area Studies (Canadian, Mediaeval, Asian, etc.)	29
30	Commerce, Management and Administration	30,32,33
31	Accounting	31
33	Hospital and Health Administration	25
34	Criminology	34
35	Economics	35
36	Geography	36
37	Law	37
38	Linguistics	38
39	Environmental Studies (Urban Planning, etc.)	39
40	Political Science	40
41	Clinical Psychology	41

TABLE 6 (cont'd)

CODE[1]	FIELD OF STUDY	CODE[2]
43	Psychology (Except Clinical and Educational)	42,43
44	Public Administration	44
45	Secretarial Science	45
46	Social Work	46
47	Sociology (Including Demography)	47
48	Social Science, n.e.s.	48
49	Agriculture	49
50	Biochemistry	50
51	Biology	51
52	Botany	52
53	Dietetics and Nutrition	53
54	Forestry	54
55	Household Science and Related, n.e.s.	55
56	Veterinary Medicine and Veterinary Sciences	56
57	Zoology	57
58	Aeronautical Engineering	58
59	Agricultural Engineering	59
60	Architecture	60
61	Landscape Architecture	61
62	Biomedical Engineering	62
63	Chemical Engineering	63
64	Civil Engineering	64
65	Electrical Engineering	65
66	Engineering Physics and Science	66
67	Geological Engineering	67
68	Industrial Engineering	68
69	Mechanical Engineering	69
70	Metallurgical Engineering	70
71	Mining Engineering	71
72	Petroleum Engineering	72
73	Engineering, n.e.s.	73
74	Dentistry	74
75	Basic Medical Sciences (Biochemistry, Pharmacology, etc.)	75
76	Medicine	76
77	Medical Specialties (e.g., Internal, Psychiatry)	77
78	Paraclinical Medical Science (e.g. Immunology, Virology)	78
79	Surgery, Surgical Specialties	79
80	Nursing	80
81	Pharmacy	81
82	Public Health and Hygiene	82
83	Rehabilitation, Occupational and Physical Therapy, Audiology	83
84	Optometry, Medical Technology, Other Health	84
85	Astronomy and Astrophysics	85
86	Chemistry	86,87, 88,89

TABLE 6 (cont'd)

CODE[1]	FIELD OF STUDY	CODE[2]
90	Computer Science	90
91	Geology and Related, n.e.s.	91
92	Mathematical Statistics	92
93	Mathematics (Including Operational, Research, Actuarial)	93
94	Metallurgy and Materials Science	94
95	Meteorology	95
96	Oceanography	96
97	Physics	97
98	General Science - No Major	98

Source: Statistics Canada, Highly Qualified Manpower Post-Censal Survey.

Notes: [1]These Codes and fields of study correspond to the list as provided in the Post-Censal Survey Data Dictionary.

[2]Codes in this column refer to the Post-Censal Survey Questionnaire.

TABLE 7

FIELD OF STUDY CLASSIFICATION
USED IN HQM MODEL

Aggregate Group	Description	HQM Category Numbers*
Health	Dentistry	74
	Medicine	76,77,79
	Pharmacy	81
	Nursing	80
	Rehabilitation Medicine	83
	Health Administration	33
	Med. & Paraclinical Sciences	75,78
	Other Health	82,84
Engineering	Architecture	60
	Chemical	63
	Civil	64
	Electrical	65
	Mechanical	69
	Metallurgical	70
	Aeronautical	58
	Mining & Geological	71,67
	Petroleum	72
	Industrial	68
	Agricultural	59
	Other Engineering	61,62,66,73
Life Sciences	Veterinary Medicine	56
	Dietetics and Nutrit.	53
	Agriculture	49
	Forestry	54
	Biochemistry	50
	Biology	51
	Botany	52
	Zoology	57
	Household Science	55
Physical Sciences and Mathematics	Geology	91
	Meteorology	95
	Chemistry	86
	Physics	97,85
	Mathematics	92,93
	Computer Science	90
	Metallurgy and Materials Science	94
	Oceanography	96
	General Sciences - No Major	98

TABLE 7 (concl'd)

FIELD OF STUDY CLASSIFICATION
USED IN HQM MODEL

Aggregate Group	Description	HQM Category Numbers*
Humanities and Fine Arts	Theology	22
	Library and Archival Science	17
	Translation	23
	Fine and Applied Arts	12,13
	History	16
	English	18
	French	19
	Modern Languages	20
	Classics and Philosophy	15,21
	Journalism, Creative Writing and Humanities, n.e.s.	24
Education	Secondary	5
	Elementary	1
	Educational Admin.	8
	Counselling	7
	Special Educaton	2
	Other Teaching Fields	3,4,6
	Educ. Psychology	9
	Other Non-Teaching Fields	10,11
Law	Law	37
Commerce, Administration, & Accounting	Accounting	31
	Commerce & Admin.	25,30
Social Sciences	Social Work	46
	Clinical Psychology	41
	Psychology (Other)	43
	Economics	26,35
	Anthropology, Archaeology, Area Studies	27,28,29
	Geography and Environ. Studies	36,39
	Political Science	40
	Sociology, Demography, Criminology	34,47
	Linguistics	38
	Other Social Sciences	48
General Arts	General Arts	0

* These categories are defined in the Highly Qualified Manpower Survey Data Dictionary.

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